Machinery Messages
Case History

The importance of integrating critical process data in your machinery management system

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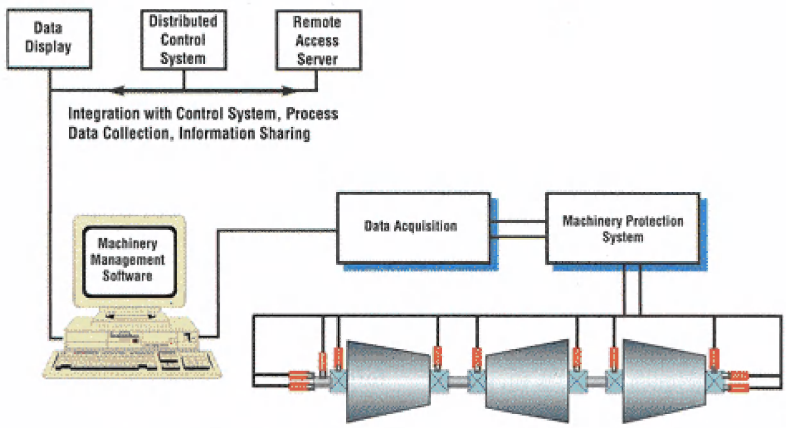


Figure 1. Typical Machinery Protection and Management System.

Industry has accepted vibration monitoring of critical and essential rotating machinery as the best way to provide continuous protection against detrimental vibration or thrust conditions. What has yet to be fully appreciated is the necessity of integrating critical process data with vibration and position data in machinery protection and management systems to provide event correlation and performance monitoring, and to allow for effective root cause analysis.

The availability of comprehensive vibration and position data has allowed our customers to solve many problems. But, as most experienced machinery engineers will attest, more than just vibration data is required. This other information is in the form of process-related data. In many situations, machinery behavior is affected by the process conditions. Conversely, the process can also be affected by the machine vibration characteristics. The machine and the process are inseparable, and our management philosophy must reflect this interaction if we are to become more effective in solving problems and keeping machines online.

Machinery protection systems must track critical parameters, provide notification and shutdown protection in the event of an unusual occurrence, and provide crucial information for early identification of developing machinery problems. Solving many of these problems first requires the acquisition of sufficient data to provide insight into rotor dynamic responses.

But what is sufficient data?

The larger rotating machines – such as gas and steam turbines, compressors, motors, generators, pumps, and fans – are generally equipped with fluid film radial and thrust bearings. The radial bearings are instrumented with XY proximity probes to provide shaft relative vibration and position information. Thrust bearings are also instrumented with proximity probes to provide axial position measurements. Casing (seismic) vibration transducers are installed when foundations and bearing supports allow significant housing motion. Machines using rolling element bearings are generally monitored only with seismic transducers. Keyphasor® probes should be used on all machines to provide speed and phase measurements. The vibration and position data provided by these transducers plays a major role in identifying malfunctions, such as unbalance, rubs, fluid-induced instabilities, loose parts, bearing deterioration, misalignment, shaft cracks, motor electrical

problems, structural resonances, etc.

To fully realize the benefits of data correlation and performance monitoring in a machinery management program, the vibration data must be integrated with the process data (which is always available within the plant) and made available at the machinery management system (Figure 1).

Bently Nevada data acquisition and display systems, such as our Data Manager® 2000 (DM2000), and machinery management systems, such as our Machine Condition Manager™ 2000 (MCM2000), directly interface with machinery protection systems, such as the 3500.

Communications processors automatically collect, process, and store all available vibration and process data during steady state and transient (startup or coastdown) machine operation, and send it to the computer. A single system can simultaneously acquire data from many machines. There is no point-by-point polling, as in multiplexed systems - all points are simultaneously sampled and stored. Static and dynamic data can be viewed in a variety of formats: bar graphs, machine train diagrams, trends, and diagnostic plot formats, such as orbit/timebase, full spectrum, polar, Bode, shaft centerline, etc.

Additionally, the DM2000 and MCM2000 systems can be accessed via modem from remote locations, a powerful and liberating feature that allows us to Move Data, Not People®, providing communication and analysis of data from anywhere.

But again we must ask ourselves, what data is sufficient? The following recommendations for process data are organized by the class of machinery being monitored.

Gas turbines

It is easy to see the interaction of process and vibration characteristics by studying industrial and aeroderivative gas turbines, because they are really three machines in one. They are a compressor that pressurizes ambient air, a combustor that introduces fuel and burns the air/fuel mixture, and an expansion (or power) turbine through which the hot, high pressure combustion gases expand, driving the compressor and any other connected machinery.

Gas turbines are subject to wide performance and vibration variations when ambient air, fuel, or load values change. For example, high inlet air temperature reduces gas turbine performance, requiring higher fuel consumption for a specific power level. Conversely, low air temperature causes the power to increase. If humidity is high, ice can form on the inlet filters, inlet ducting, and inlet casing of the compressor. Large accumulations of ice reduce and distort the airflow, which may cause compressor stall and surge.

The following parameters, as a minimum, should be incorporated into the machinery management system:

- Fuel flow
- Ambient temperature and pressure
- Inlet pressure and temperature
- Discharge pressure and temperature
- Inlet guide vane (IGV) position
- NO_x water injection rates (if applicable)
- Total power generated (kW) or shaft speed and torque
- Kvars (generator drive applications)
- Fuel heating value
- Relative or absolute humidity
- Exhaust temperature
- Bearing metal and oil drain temperatures

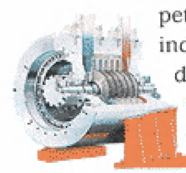
Steam turbines

Steam turbines are used in almost every industry for driving compressors, generators, pumps, and other equipment. Sizes vary from small, single stage units of less than 100 hp to large power generation units capable of over 1,000 MW in a single machine train. However, despite these size variations, steam conditions generally provide significant insight into any rotor response changes, such as rubs and shaft bow. Process variables that should be monitored on each driver include:

- Steam supply and exhaust conditions - temperature, pressure, flow, quality
- Extraction conditions (if applicable)
- Condenser vacuum
- Bearing metal and oil drain temperatures
- Gross generation (kW) or shaft speed and torque
- Reheat steam conditions (if applicable)
- Kvars (generator drive applications)

Centrifugal compressors

The compressor is one of the petrochemical industry's most durable and dependable machines. In general, there is a more limited set of variables to be monitored in compressors than in gas and steam turbines, which helps when you are analyzing and troubleshooting. However, rotational speeds tend to be much higher. The following process parameters are considered key items:



- Suction pressure and temperature
- Discharge pressure and temperature
- Product (gas) flow rate
- Gas analysis (mole weight)
- Compressor speed
- Driver power
- Bearing metal and oil drain temperatures

Centrifugal pumps

Pumps are found in nearly every industry in a wide array of sizes and capacities. Larger pumps, such as boiler feed pumps and reactor recirculation/coolant pumps, are often permanently monitored, though many smaller units are not. Regardless, the following parameters are necessary to effectively evaluate process-related phenomena:

- Speed
- Suction pressure and temperature
- Discharge pressure and temperature
- Flow
- Bearing metal and oil drain temperatures
- Driver power

Generators

Generators are generally well-behaved dynamically, due to their less complicated construction, compared to gas and steam turbines. Unbalance, thermal bows, and seal rubs comprise the majority of problems seen. The process variable list reflects this:

- Output (kW or MW)
- Reactive loading (vars)
- Power factor
- Coolant gas temperature and pressure
- Winding temperatures
- Field current
- Bearing metal and oil drain temperatures

Connectivity

After deciding which process variables are important for a given machine, they must be integrated with the vibration data in a machinery management system. We can acquire most of the process data via direct digital links with plant process computers and process controllers. These links are implemented by use of a serial Modbus®/DDE protocol or by network communications using the NetDDE or OLE for process control (OPC) protocols, which can also be used to supply vibration data to the plant computers.

The density of process data acquired varies with configuration options. The typical sample rate using network communications is one sample every 4 seconds. Higher data densities can be achieved by using the TDXnet Communications Processor to sample signals connected to the 3500 Process Variable Monitor. The signals can be sampled at delta-time and delta-rpm intervals, just like vibration signals.

Conclusion

With the advances in digital communication speeds and the increased ease of network connectivity, there is little reason not to integrate critical process data into your machinery management system. By trending and correlating performance and vibration data, you are assured of better results and will also achieve a capable system for managing your machinery.

In Memoriam

We regret to inform our readers of the death of Professor Dr. -Ing. hab. Konstantin P. Seleznev. He died on July 14, 1998 at the age of 78, as a result of a stroke. From 1960 to 1989, Professor Seleznev was the head of the Compressor Department of Saint-Petersburg State Technical University (formerly the Leningrad Polytechnic Institute). He was the most active and esteemed member of this group, and was considered to be the heart and soul of the department, which he created in its current form. Professor Seleznev was also the Rector of the University for ten years.

Professor Seleznev specialized in three main areas:

- Theoretical and practical research in the field of centrifugal compressor design.
- Development of methods for analyzing and calculating the thermal conditions of steam turbines, gas turbines, and nuclear reactors.
- Theoretical research and design of hydrogen compressors.

He founded the Compressor & Pneumatic Association and was its Chairman until his death. He was also the Chief Editor of *Compressors and Pneumatics* magazine. Hundreds of his former students work in industry, research centers, and universities. He made an enormous contribution to the field and will be truly missed.